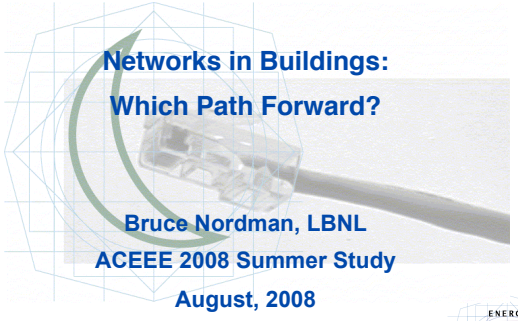
Networks in Buildings: Which Path Forward?



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Overview

- Network Concepts
- Possible Futures
- Strawman Architecture
- Difficult Topics
- Next Steps

Building Networks

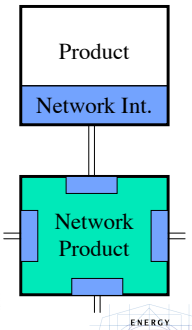
- Electronics
  - Products whose primary function is information (acquire, process, store, transmit, display)
- Lighting
- Climate Control
- Security
- Other (Appliances, Misc.)

- Future: All one network
  - separation only for illustration

Key Network Concepts

How networks drive energy use

- Direct
  - Network Interfaces (NICs)
  - Network products
- Induced in Networked products
  - Increased power levels
  - Increased time in higher power modes



Connection types

- Data: 2 products
- Network: 3 or more products

Key Network Concepts, cont.

OSI Network Model

#	Name	Function
7	Application layer	"I want a web page"
6	Presentation layer	.
5	Session layer	.
4	Transport layer	.
3	Network layer	.
2	Data link layer	.
1	Physical layer	"Bits on a wire" (or non-wire)

(8th layer — User Interface)

Key Network Concepts, cont.

OSI Network Model

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Key Advantages
- Can replace individual layers without affecting higher and lower layers
- Facilitates interoperability
- All revolves around Internet Protocol

(8th layer — User Interface)

Past Experience with Networks

- **IT Networks**
  - Not designed with Energy in mind
  - Energy people not involved in design
  - "Tacking on" energy features not successful
  - Community not opposed to working with energy people
- **CE Networks**
  - A mess at all layers
  - Energy/efficiency not a priority
  - Progress possible if we do most work and use leverage
- **Sensor Networks**

Your CE Future ?

While some integrators are skeptical about the prewired, preprogrammed NHS rack from Sony, others embrace the solution for its simplicity.

Imagining the Future

- **Incrementalism** (alone) **the path to nowhere**
  - **Need quantum leaps to make significant progress**
  - **Internet is a key example**
  - **Incrementalism is how to implement**
- **Figure out where we want to get to …**
  - **… then chart path from here to there**

Let's consider two possible futures (2028) …

A "Darwinian" Future

*Highly networked buildings use **more** energy than others*

- Building networks installed principally for reasons other than saving energy.
- Promoters of specific (physical layer) technologies pursue their advantage at the expense of interoperability.
- Efficiency an afterthought in network and product design.
- Energy efficiency not a major player in standards development.
- User interfaces neglected.
- Little coordination across end uses.

An "Intelligent Design" Future

*Highly networked buildings use significantly **less** energy*

Based on open international standards, and have:

- Sensors for occupancy, temperature, and ambient light.
- Controls that take into account presence*.
- Dynamic capabilities — temperature, light, façade, …
- Lighting that tracks activity.
- Climate control that follows preferences, outdoor climate (to indicate clothing), and occupancy.
- Preferences expressed through many means.
- Displays coordinated with occupancy and lighting.
- Diagnostics that make equipment failure easy to deal with.

(Some) **Necessary steps for a good future**

- **Adopt standard network technology up through TCP/IP**
- **Adopt goal of "universal interoperability", across:**
  - **Countries, time, end uses, building types, etc.**
- **Be prepared to jettison any/all existing technology**
- **Engage network research community into design of network architecture for buildings**
- **Start on this ASAP**

A sketch of a model

Network architecture for buildings

- Proposed 5-layer model for building control networks (apologies to OSI)

	User Interface	*<= One Standard*
Diverse Standards =>	Applications	
	Communication*	*<= One Standard*
	Concepts*	*<= One Standard*
	Transport	*<= One Standard*
Diverse Standards =>	Network, Data Link, Physical	

- Policy and authority among multiple entities in buildings also key
- Global standards and diversity both essential for networks to be effective and usable

**Concepts may not be a true layer*

Transport - Physical Layers

- **Don't pick "winners"**
  - **But don't be surprised by success of IEEE 802**
- **All buildings will have multiple wired and wireless physical layer technologies**
  - **Will evolve over time**
- **Sensor networks are a special case**
  - **This discussion does not apply**

Concepts

- **Standardization of core ideas, terms, and underlying metaphors**
  - the meaning (semantics) of the information
  - not how it is encoded or represented (except in the UI)
- **Examples**
  - Building elements (energy using or not) - lights, climate control devices, windows, displays, and appliances
  - Ideas - presence, schedules, prices, and events
  - Characteristics - physical location, power levels, light
  - Existing example standard concepts
    - ASCII, fonts, folders, PDF, HTML
- **"Presence" a key concept**
- **A "vocabulary" of nouns**

Communication

- **Transmit information about identity, status, characteristics, requests, …**
- **Negotiate policies about control**

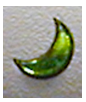
Application

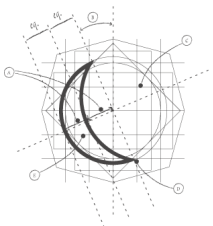
- **Application layer is about making decisions**
- **Need to facilitate multiple models for decision-making**
- **Locus of authority a key issue**

User Interfaces

- **Consistent across:**
  - **Manufacturers**
  - **Products**
  - **Countries**
- **Simple**
- **Accessible**
- **Portable**

"Universal"





Key Issues

- **Presence**
  - **How to sense, indicate**
  - **Types**
- **Authority**
  - **Who has it? When?**
  - **Adapting to circumstances**
- **Security / Privacy**
- **Anomalies**
  - **Device failure**
  - **Emergencies**

Next Steps

- Adopt Building Network design as a key efficiency priority
- Fund academic research on key topics
  - Presence, authority, security, user interfaces, network architecture, protocol design, …
- Create new institutions as needed
- Revisit related topics in light of this
  - Real-time pricing, demand response, “smart grids”, …
- Get started ASAP

Thank you!